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SHOREBIRD SURVEYS IN ENSENADA PABELLONES AND BAHIA SANTA MARIA, SINALOA, MEXICO: CRITICAL WINTER HABITATS FOR PACIFIC FLYWAY SHOREBIRDS

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ABSTRACT.—On 6–9 December 1993 and 14–18 February 1994 ground surveys of shorebirds were conducted in Ensenada Pabellones and Bahia Santa Maria, Sinaloa, Mexico. These were the first comprehensive ground surveys of shorebirds conducted in western Mexico. Twenty-nine species of shorebirds were recorded. The composition was characterized by those species spending their non-breeding period on the Pacific Coast of North America. Total numbers of shorebirds estimated were 340,063 birds (December) and 405,483 birds (February) in Ensenada Pabellones and 248,044 birds (December) and 389,841 birds (February) in Bahia Santa Maria. Western Sandpiper (*Calidris mauri*) comprised 82% of shorebirds present in both bays. American Avocet (*Recurvirostra americana*; 6% average total), dowitchers (*Limnodromus* spp.; 6% average total), and Least Sandpiper (*Calidris minutilla*; 3% average total) were also abundant. These bays hold approximately 30% of the shorebirds wintering in Pacific coastal regions of North America. Using Western Hemisphere Shorebird Reserve Network criteria, both bays are of international importance for shorebirds. Ensenada Pabellones is of regional importance for American Avocets supporting nearly 10% of the total world population. Both bays would qualify as wetlands of international importance as defined by the Ramsar Convention on international wetlands. *Received 28 Aug. 1997, accepted 18 April 1998.*

Many North American breeding birds are Neotropical migrants that move to wintering areas in South and Central America (DeGraaf and Rappole 1995, Hagan and Johnston 1992). The decline of habitats in Neotropical countries has become an international concern for both forested and wetland systems. In particular, coastal wetlands and estuaries have suffered significantly and future economic development continues to threaten these important sites of waterbird diversity (Bildstein et. al 1991). Most of North America's over 50 species of shorebirds depend on coastal wetlands in the Neotropics during the non-breeding season. Indeed, many authors have acknowledged that Nearctic breeding shorebirds are true Neotropical migrants (Rappole et al. 1983; Morrison and Ross 1989; Morrison and Myers 1987, 1989). Surveys conducted by the Canadian Wildlife Service (CWS) around all of South America identified important wintering sites for many North American breeding shorebirds (Morrison and Ross 1989). Recent efforts by the CWS (Morrison et al. 1992, 1993, 1994), combined efforts of U.S. Fish and Wildlife Service (USFWS), Point Reyes Bird Observatory (PRBO; Page et al. 1992, 1997), and Manomet Observatory for Conservation Science (MOCS; Harrington 1992, 1993, 1994) have called attention to the importance of Mexican and Central American wintering sites. Aerial surveys from 1992–1994 were used to assess and rank the importance of the coastal bays of western Mexico for wintering shorebirds (Harrington 1992, 1994; Morrison et al. 1992, 1994).

In April 1993, a field reconnaissance of the northern two-thirds of Sinaloa's coastal wetlands was conducted by Ducks Unlimited de Mexico (DUMAC) and Ducks Unlimited, Inc. (DU). This survey was part of an effort to characterize the resources of Sinaloa's coastal bays and to develop a comprehensive regional conservation plan. The April reconnaissance further revealed that aerial surveys had underestimated small shorebird numbers and did not clarify species composition. We confined

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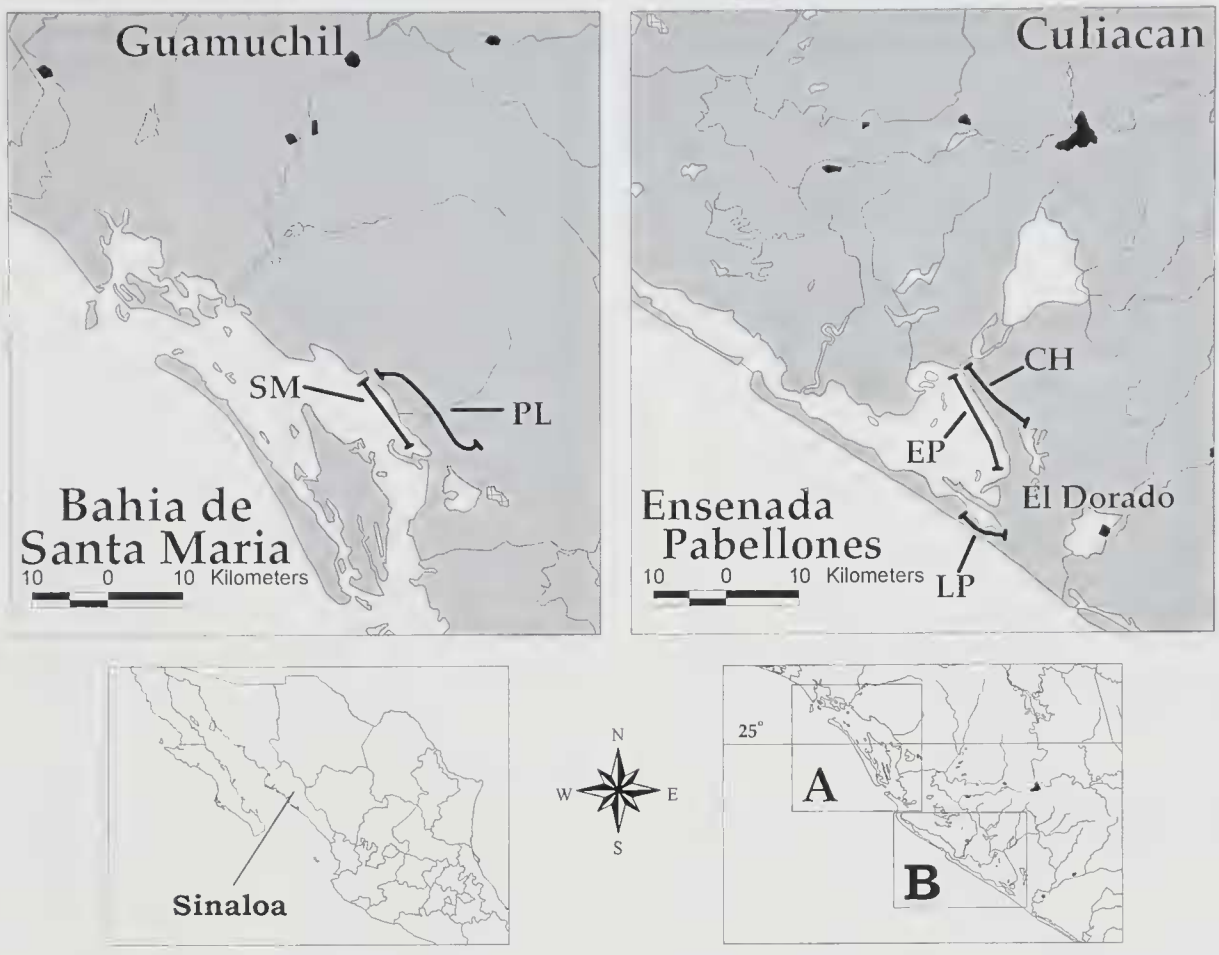

FIG. 1. Ensenada Pabellones and Bahia Santa Maria transect locations. Transect abbreviations: SM = Santa Maria, PL = Patolandia, EP = Ensenada Pabellones, CH = Chiraehueto Marsh, LP = Lucenilla Peninsula.

our shorebird surveys to two bays: Bahia Santa Maria and Ensenada Pabellones (Fig. 1). These bays are important as shorebird and waterfowl stopover sites, but they are also important to the Mexican economy. Economic activities in and around the marshes is dominated by agriculture, commercial fishing, and a rapidly developing shrimp industry. The marshes also support hunting outfitters and ecotourism. Further development of these bays is planned. The aim of DUMAC's surveys has been to document the region's wildlife resources and to ensure that the conservation of these resources remains one of the priorities for future economic development. The team focused its survey efforts on the region's shorebirds to supplement the abundant waterfowl data already available for these bays (Saunders 1981, Kramer and Migoya 1989). We also documented overall avian diversity (Engilis and Carrera, in press).

STUDY AREA AND METHODS

Ensenada Pabellones.—Ensenada Pabellones is a diverse coastal estuary eneompassing 800 km^2 (Scott and Carbonell 1986). Shorebirds inhabit the extensive intertidal flats (inner bay) and mangrove lined mudflats (outer bay; Fig. 1). Our reeonnaissance trip on 23 April 1993 and data from MOCS and CWS surveys (Harrington 1992, 1993, 1994; Morrison et al. 1992, 1994) indicated that three regions of the bay were important for shorebirds. Transects were established in these regions.

Transect Chirachueto (CH) covered the interior marshes and estuary between uplands and mangrove edge (Fig. 1). Transect Chiraehueto was 14 km long and ineluded eight point-count stations. Water depth varied from 0–10 cm. The area was under tidal influence but remained covered by water beeause of slow drainage. A distinct hypopycnal zone marked the transition from freshwater to brackish water. Brackish flats were coated with algae. Emergent vegetation was characterized by *Scirpus* flats mixed with various speeies of sparsely growing *Spartina, Sesuvium,* and *Disticilis.* Intertidal zones were eomposed of exposed, firm mud. Floating aquatic plants were dominated by *Ruppia.* In freshwater areas where irrigation runoff entered the bay, the marsh was overgrown by stands of *Typha* and *Scirpus.* Floating vegetation included *Ruppia* and *Najas. Eichhornia* ereated large floating mats that moved with prevailing winds and tidal flow.

Transeet Ensenada Pabellones (EP) covered the eastern, interior shoreline of Ensenada Pabellones. This

shoreline was 17 km long and was bounded by a ridge of mangrove (*Rhizophora* spp.) The transect was 14 km long and included eight point-count stations. Small channels through the mangroves allowed for limited exchange of tidal waters with the interior marshes of Chircahueto. The outer bay was characterized by a liquefied mud-mass more than 50 cm thick. The mud would not support a human but was passable by airboat. There was no aquatic vegetation on the flats. The mudflats were exposed to a width of 1–2 km at low tide, and were completely submerged at low tide. Mangroves were established on ridges of firm mud that ran parallel to the flats.

Transect Lucenilla (LP) covered a complex wetland zone created by dune formation on the Santa Eleana Peninsula (Fig. 1). Transect Lucenilla was 2 km long and included two point-count stations. Water in this back-dune wetland was fresh to brackish. The back-dune wetlands were highly variable from *Spartina-Disticilis-Scirpus* dominated marsh to open alkali flats. Some of the flats were lined by mangroves. The back-dune wetlands were marginally affected by tides, but water depths varied as a result of surface inflow of freshwater. The remainder of the area was covered by dense mangrove. The transect passed through habitats that have been degraded by the construction of shrimp ponds.

Bahia Santa Maria.—Bahia Santa Maria is a 1350 km^2 estuary composed of a diverse mosaic of mangrove, intertidal mudflats, freshwater marshes, extensive brackish flats, and emergent brackish marsh (Scott and Carbonell 1986). Using reconnaissance, by boat in April 1993, and by air in December 1993, we determined the placement of two transects in Bahia Santa Maria.

Transect Santa Maria (SM) covered 12 km of shoreline and included eight point-count stations. It was located along the coast south of the fishing village of La Reforma (Fig. 1). The intertidal mudflats of SM were comprised of consolidated silt and shell fragments that were capable of supporting the weight of a human. Thus, this substrate differed greatly from the unconsolidated mud of Ensenada Pabellones. The bay was surveyed on a rising tide that served to concentrate shorebirds along the water's edge. Flats of *Zostera* were evident along the shore. Otherwise, mudflats were unvegetated. Two point-count stations (SM-4 and 5) surveyed unconsolidated mud similar to that found in Ensenada Pabellones.

Transect Patolandia (PL) covered the interior marshes characteristic of Bahia Santa Maria, was 18 km long, and had five point-count stations. Habitats at these stations ranged from open, algae covered mudflats with a water depth of 4 cm to sparsely vegetated areas with water 4–20 cm deep. Dominant vegetation included *Scirpus, Salicornia, Atriplex,* and *Chenopodium.* Freshwater intrusion into the bay from agricultural runoff is transforming interior marshes to dense stands of *Typha.* The upper arms of the bay were already fully overgrown with *Typha.* A salt mining operation exists in the bay's southern reach.

Survey period and methods.—Transects were selected and established to cover intertidal flats and interior marshes, areas that received minimal coverage from MOCS and CWS aerial surveys. The three transects (18 point-count stations) at Ensenada Pabellones were surveyed on 8–9 December 1993 and 14–15 February 1994, while the two transects (13 point-count stations) in Bahia Santa Maria were surveyed on 6–7 December 1993 and 16–17 February 1994. Point-count stations were located through the use of a Trimble global positioning system device (GPS) and coordinates recorded using the UTM system. The coordinates of these data points are available from Ducks Unlimited's Western Regional Office. Airboats were used to access transects and point-count stations. The survey team was comprised of a crew member to operate the boat and at least two trained observers. Surveyors used 8× and 10× binoculars and 22× spotting scopes.

Because it was not possible to count each shorebird, we developed a sampling regime designed to estimate the number of birds present on transects. The sampling regime had two parts: (1) point counts were conducted along each transect at which birds within a 400 m circle were identified to species and counted; (2) we estimated the total number of birds along each transect line, including areas between points (to a width of 200 m). The number estimated on the transect was developed using the combined point count totals for each species as a percentage of the total birds we estimated along the transect. Thus, if we counted 50,000 birds of a given species on point counts, and that number represented 50% of the total estimated on the transect, we reported 100,000 birds for the transect. These percentages are expressed for each species in Tables 1 and 2. All stations were censused during each survey period. Each transect was characterized by habitat indicating substrate, dominant vegetation, and water depth. Where species identification was impossible, shorebirds were grouped to genus (e.g., *Calidris, Limnodromus*). Numbers of shorebirds were determined by direct counts or by flock estimations when larger concentrations were encountered. Count data were recorded onto tape recorders and transcribed to field forms. These counts were not time dependent.

The April 1993 reconnaissance revealed that airboats caused shorebirds to take flight as they approached. To minimize this problem we adopted the following protocol on all subsequent surveys. A count station was always approached at an angle perpendicular to the transect line, minimizing disturbance. When a count was completed, the airboat was driven 0.5 km away (perpendicular) from, and then parallel to the transect line, until we reached the approach for the next count station. We then turned the airboat towards the next station allowing the airboat to coast to a stop with the engine turned off. The engine was only turned on to move the boat between stations; it was not on during the survey period. The GPS units allowed us to predict when to start our approach to each station and when to turn off the engine. This tactic resulted in reduced disturbance to birds.

TABLE 1. Shorebird survey results Ensenada Pabellones.

Species		% of birds counted on transects[a]	December 1993		February 1994	
			Number counted	Total estimated	Number counted	Total estimated
Snowy Plover	*Charadrius alexandrinus*	60%	63	105	54	90
Semipalmated Plover	*Charadrius semipalmatus*	60%	174	290	109	182
Killdeer	*Charadrius vociferus*	20%	8	40	17	85
Wilson's Plover	*Charadrius wilsonia*	60%	5	8	2	2
Black-bellied Plover	*Pluvialis squatarola*	40%	289	723	37	93
American Oystercatcher	*Haematopus palliatus*	—	—	—	2	2
Black-necked Stilt	*Himantopus mexicanus*	20%	367	1835	638	3190
American Avocet	*Recurvirostra americana*	40%	15,702	39,255	11,792	29,480
Spotted Sandpiper	*Actitis macularia*	—	2	2	1	1
Sanderling	*Calidris alba*	—	—	—	45	45
Red Knot	*Calidris canutus*	20%	200	1000	40	200
Stilt Sandpiper	*Calidris himantopus*	30%	48	160	311	1037
Dunlin	*Calidris alpina*	60%	417	695	30	150
Western Sandpiper	*Calidris mauri*	30%	82,767	275,890	99,906	333,020
Least Sandpiper	*Calidris minutilla*	30%	3235	10,783	61	203
Willet	*Catoptrophorus semipalmatus*	40%	349	873	313	782
Common Snipe	*Gallinago gallinago*	—	—	—	2	2
Dowitcher species	*Limnodromus* spp.	—	—	—	12,450	20,750
Short-billed Dowitcher	*Limnodromus griseus*	60%	1928	3213	450	750
Long-billed Dowitcher	*Limnodromus scolopaceus*	60%	2028	3380	7978	13,297
Marbled Godwit	*Limosa fedoa*	50%	729	1458	953	1906
Long-billed Curlew	*Numenius americanus*	20%	18	90	4	20
Whimbrel	*Numenius phaeopus*	20%	40	200	16	80
Lesser Yellowlegs	*Tringa flavipes*	50%	21	42	44	88
Greater Yellowlegs	*Tringa melanoleuca*	50%	10	20	14	28
Red-necked Phalarope	*Phalaropus lobatus*	—	1	1	—	—
Total			108,401	340,063	135,269	405,483

[a] Percentage reflects the number of birds counted on stations in relation to the number of birds estimated on the transect (e.g., the 82,767 Western Sandpipers counted on stations represent 30% of the total estimated on the transect).

Relative abundance (% composition) was calculated for each species. Since Western Sandpipers (*Calidris mauri*) outnumbered all others, relative abunance was expressed both with Western Sandpiper numbers included in the total and omitted from the total.

RESULTS

At Ensenada Pabellones, 108,401 individuals of 22 shorebird species were counted at point count sites in December 1993. The total number of birds along transects was estimated to be 340,063 (Table 1). In February 1994, 135,269 individuals of 24 shorebird species were counted; 405,483 were estimated along transects. During both surveys, Western Sandpiper was the most abundant species followed by American Avocet (*Recurvirostra americana*), dowitchers (*Limnodromus* spp.), and Least Sandpiper (*Calidris minutilla*). In December, Ensenada Pabellones accounted for 58% of the shorebirds surveyed in both bays; in February 51%.

At Bahia Santa Maria, 78,259 individuals of 24 shorebird species were counted on survey points in December 1993. The total number of birds along transects was estimated to be 248,044 (Table 2). In February 1994, 130,657 individuals of 24 shorebird species were counted on survey points; 389,841 were estimated on transects. During both surveys, Western Sandpiper was the most numerous species followed by dowitchers, Least Sandpipers, Dunlin (*Calidris alpina*), and American Avocets. The species are summarized below in order of abundance.

The Western Sandpiper was the most abundant shorebird in both bays and in both count periods. They comprised 80% of all shorebirds identified in both bays. Considering the

TABLE 2. Shorebird survey results Bahia Santa Maria.

Species		% of birds counted on transects[a]	December 1993		February 1994	
			Number counted	Total estimated	Number counted	Total estimated
Snowy Plover	*Charadrius alexandrinus*	20% Dec, 60% Feb	11	55	222	370
Semipalmated Plover	*Charadrius semipalmatus*	60%	10	17	44	73
Killdeer	*Charadrius vociferus*	20%	14	70	14	70
Wilson's Plover	*Charadrius wilsonia*	60%	50	83	18	30
Black-bellied Plover	*Pluvialis squatarola*	60%	262	437	45	75
American Oystercatcher	*Haematopus palliatus*	—	4	4	3	3
Black-necked Stilt	*Himantopus mexicanus*	20%	823	4115	571	2855
American Avocet	*Recurvirostra americana*	60%	1036	1727	3889	6482
Spotted Sandpiper	*Actitis macularia*	—	4	4	2	2
Ruddy Turnstone	*Arenaria interpres*	20%	88	440	83	415
Sanderling	*Calidris alba*	60%	2468	4113	36	60
Red Knot	*Calidris canutus*	20%	341	1705	133	665
Stilt Sandpiper	*Calidris himantopus*	60%	404	673	482	803
Western Sandpiper	*Calidris mauri*	30%	60,547	201,823	99,530	331,767
Least Sandpiper	*Calidris minutilla*	30%	6479	21,597	855	2850
Willet	*Catoptrophorus semipalmatus*	40%	861	2153	1958	4895
Common Snipe	*Gallinago gallinago*	—	2	2	—	—
Dowitcher species	*Limnodromus* spp.	60%	—	—	14,437	24,062
Short-billed Dowitcher	*Limnodromus griseus*	60%	902	1503	503	838
Long-billed Dowitcher	*Limnodromus scolopaceus*	60%	2760	4600	7087	11,811
Marbled Godwit	*Limosa fedoa*	50%	1014	2028	670	1340
Long-billed Curlew	*Numenius americanus*	20%	54	270	29	145
Whimbrel	*Numenius phaeopus*	20%	60	300	25	125
Lesser Yellowlegs	*Tringa flavipes*	20%	21	105	3	15
Greater Yellowledgs	*Tringa melanoleuca*	20%	44	220	18	90
Total			78,259	248,044	130,657	389,841

[a] Percentage reflects the number of birds counted on stations in relation to the number of birds estimated on the transect (e.g., the 60,547 Western Sandpipers counted on stations represent 30% of the total estimated on the transect).

widespread distribution of this species, and the limited coverage of our transects, our estimate of over 600,000 birds should be considered a minimum number. Our April 1993 estimate of 1,000,000 *Calidris* sandpipers (850,000 westerns) indicates that these bays also support Western Sandpiper through their migration period. Western Sandpipers foraged predominantly in shallow water of open and semi-open flats. They exhibited the widest variety of substrate use, and were one of the few species that regularly exploited algal flats. Western Sandpipers characteristically foraged in dense flocks, some numbering 25,000 birds or more. Frequently they were joined by other *Calidris* species. Flocks of Western Sandpipers regularly flew between interior wetlands and intertidal flats, moving to the intertidal habitats during low and receding tides. Interior wetlands were the preferred roost sites for Western Sandpipers.

American Avocets were concentrated, often in large aggregations, on the eastern shoreline of Ensenada Pabellones. Birds foraged in liquefied mud, particularly along the receding or increasing tidal water edge. Peak estimated numbers at Ensenada Pabellones exceeded 39,000 birds (Table 1). Avocets were also counted in Chircahueto Marsh loafing in flocks on exposed mudflats, particularly at high tide. Some birds foraged along the edges of the interior marsh on flooded mudflats. Peak counts in this interior area exceeded 4000 birds (December). Avocets were not as abundant in Bahia Santa Maria. They were concentrated on the bay's interior, marsh-lined mudflats. They avoided the consolidated siltshell flats characteristic of the eastern shoreline, but frequented liquefied mud at point-count stations SM7 and SM8 (off shore from La Reforma). Avocets were not found on the algal covered, intertidal flats characteristic of

Bahia Santa Maria. Peak counts in Bahia Santa Maria exceeded 6400 birds (February survey period). American Avocets were one of three co-dominant species with a relative abundance of 5–7% in both bays. When compared to other shorebirds but omitting Western Sandpiper counts, relative abundance was 28–38%.

Dowitchers of both species were found in both bays. They sorted themselves between habitats in December. Short-billed Dowitchers (*Limnodromus griseus*) occurred primarily on intertidal flats of consolidated and liquefied mud while Long-billed Dowitchers (*L. scolopaceus*) occurred in the shallow flooded, interior wetlands along the margins of small flats, ponds, channels and bays. The latter species infrequently visited intertidal flats. In February, this pattern changed. Census totals jumped from 12,000 birds in December (combined species in both bays) to nearly 70,000 birds (combined species in both bays; Tables 1, 2). In February dowitchers no longer sorted themselves between habitats as both species frequented intertidal flats. During February we had to count birds to "dowitchers only." Dowitchers were another co-dominant shorebird representing 2% of the total birds surveyed in December and 9% in February. When relative abundance is compared between all shorebirds, omitting Western Sandpiper numbers, dowitchers represented 11% in December and 57% in February.

Least Sandpipers were distributed in linear bands of mudflat along vegetated margins. This spacing and distribution made accurate surveys of this species difficult. In some instances, especially where water depths were 2–4 cm or less, Least Sandpipers were mixed with Western Sandpipers, but their numbers varied. For example, on 6 December 1993 at Station PL3, we observed 4700 Least Sandpipers with 39,000 Western Sandpipers and 2400 Dunlin. On 16 February 1994, this same station yielded 74,000 Western Sandpipers and only 815 Least Sandpipers and 10 Dunlin. Least Sandpipers comprised nearly 6% of total birds in both bays in December 1993. The February surveys counted only 3000 birds. The 10 fold decline may be the result of birds migrating north, or moving to other areas of the bays.

Black-necked Stilts (*Himantopus mexicanus*) were evenly distributed throughout the interior wetlands, frequenting mudflats and shallow flooded habitats of both bays. They were usually observed in pairs, rarely in large aggregations. At Ensenada Pabellones, stilts were most numerous in the shallow interior brackish flats and freshwater ponds and channels of Lucenilla and Chircahueto marshes. They were rare in the liquefied mud substrate in Ensenada Pabellones during both survey periods. Peak numbers exceeded 3000 birds in Ensenada Pabellones (Table 1). In Bahia Santa Maria, stilts frequented the vegetated interior wetlands, channels, and ponds. They were also found on the shallow inundated silt-shell substrate and liquefied mud near La Reforma. Peak counts in Bahia Santa Maria exceeded 4100 birds (Table 2). Stilts had a relative abundance of 1% in both bays in December. When Western Sandpiper counts were removed from calculated totals, stilts comprised 5% of total birds.

Stilt Sandpipers (*Calidris himantopus*) were regularly counted in all interior wetland habitats. They associated with other *Calidris* and dowitchers. Because of their tendencies to be interspersed with other species, our point-counts included only 30% of the total estimated to occur along the transects. Stilt Sandpipers foraged in shallow water on mud or algal covered flats. They preferred flooded areas and were infrequently observed on intertidal margins. Stilt Sandpipers represented 1% of all shorebirds (excluding Western Sandpiper numbers).

Marbled Godwits (*Limosa fedoa*) were mostly restricted to intertidal flats. They were evenly distributed across a wide range of substrates from consolidated flats to liquefied flats along the water's edge. Chiriaqueto marshes provided a significant roost site for godwits foraging in Ensenada Pabellones. Godwits were equally distributed between bays. We estimated over 10,000 godwits in Bahia Santa Maria and over 1000 birds in Chiriaqueto marshes during the April 1993 survey. Godwits comprised 3% of total shorebirds (excluding Western Sandpiper numbers).

Willets (*Catoptrophorus semipalmatus*) were most abundant on the eastern shoreline of Bahia Santa Maria where they were restricted to consolidated intertidal flats. This reach of the bay contained 70–85% of the to-

tal Willets in both bays. In April, 1993 we estimated 2000 Willets along Santa Maria's eastern shore. Willets comprised 3–4% relative abundance counted in both bays (excluding Western Sandpiper numbers).

The following species represented less than 1% relative abundance, but were regularly encountered.

Six species of banded plovers were observed in both bays. One individual Collared Plover (*Charadrius collaris*) was observed 24 April 1993 at Chircahueto Marsh. Snowy Plover (*Charadrius alexandrinus*) and Semipalmated Plover (*Charadrius semipalmatus*) were common on small alkali flats of the Lucenilla Peninsula (Transect LP). Snowy Plovers also were present along the beach front of Lucenilla. Semipalmated and Snowy plovers were observed on exposed, interior wetlands in Bahia Santa Maria. Wilson's Plovers (*Charadrius wilsonia*) were documented on Lucenilla Peninsula as well as on exposed, consolidated mudflats of Bahia Santa Maria. Killdeer (*Charadrius vociferus*) were recorded in small numbers along the margins of the interior marshes, and occasionally on consolidated tidal flats.

Black-bellied Plovers (*Pluvialis squatarola*) were present and sparsely dispersed along the margins of intertidal flats, often in association with Willets and Marbled Godwits. We found no roosting concentrations of Black-bellied Plovers. They were most often found on consolidated mudflat substrates and along mangrove margins.

Dunlin were irregularly encountered during our surveys. When observed they were in flocks with other *Calidris*. Dunlin were mostly observed foraging on shallow, open mudflats of interior wetlands. They were infrequent on algal covered flats and intertidal, liquefied mudflats. In April 1993, we estimated over 10,000 Dunlin at Bahia Santa Maria indicating that this bay supports spring transients that probably winter farther south.

Red Knots (*Calidris canutus*) made extensive use of ocean strand habitats, making our estimates of this species relatively inaccurate. Knots occurred primarily on silt-shell consolidated substrate of Bahia Santa Maria (over 1700 birds). We also encountered a sizable number on mangrove margin mudflats at Ensenada Pabellones (1000 birds). During winter surveys knots infrequently were observed on interior wetlands. However, on 23 April 1993 we observed over 1000 knots in breeding plumage on the interior marshes of Chircahueto.

Whimbrels (*Numenius phaeopus*) and Long-billed Curlews (*Numenius americanus*) occurred in small numbers in both bays. They were restricted to the higher, consolidated intertidal flats and mangrove edge, being evenly distributed along the margins of both bays. The reclusive behavior of curlews, ducking into the mangrove when frightened, made estimating their numbers difficult. However, they clearly were not abundant in either bay during winter. Whimbrels were more abundant during the April 1993 survey, when over 1000 birds were observed in Bahia Santa Maria.

DISCUSSION

U.S. Fish and Wildlife surveys and banding recoveries have shown that most waterfowl wintering in western Mexico originate and move through traditional "Pacific Flyway" corridors (Kramer and Migoya 1989, Saunders 1981). Over 250,000 Nearctic nesting ducks annually occur in the bays of Sinaloa during the non-breeding season (Kramer and Migoya 1989). Although banding evidence is lacking for shorebirds, the high numbers of non-breeding Western Sandpipers, dowitchers, and avocets and the lack of Semipalmated (*Calidris pusilla*), Baird's (*Calidris bairdii*) and White-rumped (*Calidris fuscicollis*) sandpipers are more characteristic of Pacific Coast species aggregations (Helmers 1992, Page et al. 1992, Jehl 1994, Page and Gill 1994).

We recorded 29 species of wintering shorebirds during our surveys (Tables 1, 2). In comparison, 24 species winter in San Francisco Bay (Harvey et al. 1992), 22 species winter in California's Central Valley (Shuford et al. 1994), and 27 species winter in coastal bays of Baja California (Page et al. 1997). This high diversity of shorebirds wintering in Sinaloa emphasizes the global importance of the region for western Nearctic nesting shorebirds.

Numerous authors have summarized the Pacific Flyway population of shorebirds (Palacios et al. 1991; Page et al. 1992, 1997; Page and Gill 1994; Gill et al. 1994) and while Baja California was identified as an important win-

TABLE 3. Comparison of survey results for shorebirds surveyed in the Pacific Coast of North America (winter survey results).

Location	Total shorebirds	American Avocets	Western Sandpiper	Dowitchers
California interior[a]	207,000	4038	2736	77,764
California Coast[b]	570,000	24,000	195,000	25,000
Baja California[c]	355,000	1500	127,000	48,000
Sonora Coast[d]	292,000	32,500	92,800[e]	8200
Northern Sinaloa Coast[d]	118,000	21,270	50,600[e]	6600
Bahia Santa Maria (1993)	390,000	6400	332,000	36,000
Ensenada Pabellones (1993)	405,000	29,500	333,000	34,500

Sources: [a] Shuford et al. 1994; [b] Page et al. 1992, [c] Page et al. 1997, [d] Harrington 1993.
[e] Includes all small *Calidris* spp.

tering area in Mexico, Sinaloa and Sonora wetlands generally were overlooked. CWS and MOCS surveys correctly identified the bays of Sonora and Sinaloa as among the most critical wintering habitats in Mexico for Pacific Flyway shorebirds (Morrison et al. 1992, 1994; Harrington 1992, 1993, 1994). With over 795,000 shorebirds estimated on our ground surveys, Ensenada Pabellones and Bahia Santa Maria apparently support nearly one-third of the shorebirds wintering in the North American portion of the Pacific Flyway (Table 3). Combined with Sonora's coastal bays and the remaining bays of Sinaloa (Topolobampo and Navachiste), the west coast of Mexico may well support over half of the shorebirds wintering on the Pacific Coast of North America.

Bahia Santa Maria and Ensenada Pabellones are sites of great importance to North American shorebirds in general, and both clearly exceed criteria of the Western Hemisphere Shorebird Reserve Network for classification as International Sites (i.e., host to >100,000 shorebirds). These bays may be elevated to sites of Hemispheric importance (i.e., host to >500,000 shorebirds) if more comprehensive surveys are undertaken.

Previous attempts to count shorebirds in western Mexico have been from the air only. Aerial surveys are most accurate in estimating moderate to high numbers of large, conspicuous and relatively clumped birds. Yet the value of estimates may vary as a result of factors such as species mobility and seasonal habitat conditions. For example, MOCS and CWS surveys have documented large numbers of avocets at Marismas Nationales, 220 km south of the study area (R. I. G. Morrison, pers comm.). Given the high mobility of avocets, it is not unreasonable to expect movements of birds between Marismas and coastal Sinaloa bays (Robinson and Oring 1996). On the other hand, Harrington (1993) estimated only 528 Black-necked Stilts at Bahia Santa Maria and 8 at Ensenada Pabellones, whereas we estimated 4115 and 1835 along our transects in December and 2855 and 3190 in February. Furthermore, we believe that our census of this species also underestimated the numbers present. Clearly, aerial surveys were inadequate for counting stilts because of their wide dispersion in vegetated habitats. Our survey techniques did not adequately document the abundance of Killdeer and probably underestimated all species of banded plovers. Specialized counts focusing on *Charadrius* plovers need to be adopted to assess the importance of these bays as wintering and breeding habitats.

Our data suggest that the accuracy of aerial surveys is poor for widely dispersed species, especially those inhabiting areas far from the shoreline, such as Black-necked Stilts, plovers, and yellowlegs. In addition, aerial accuracy may be low when huge numbers of birds are present, especially when they are not linearly distributed; for example, Western Sandpipers at Bahia Santa Maria. We urge investigators to take advantage of broad coverage achieved by aerial surveys to delineate critical areas for more intensive ground surveys.

Our coverage was admittedly limited, i.e., surveys once each in December 1993 and February 1994, following a preliminary visit in April 1993. However, even such cursory

coverage revealed interesting seasonal variation worthy of additional study. For example, totals of Western Sandpipers for the two bays combined, increased from 478,000 in December to 665,000 in February. Does this reflect early departure from areas south of Sinaloa, local movements, or census error? Considering that *Calidris* numbers peak on the western coast of the U.S. in mid-April (Page et al. 1979), our high April estimates beg further investigation of migration patterns of Western Sandpipers. American Avocets were perhaps our most accurately censused species. Our counts declined from 41,000 in December to 36,000 in February. Avocets begin arriving on their Great Basin breeding grounds by late February, but a decline of just 12% might reflect census error as well as early migration or local movement (L. Oring, pers. obs.).

Perhaps the most dramatic variation from December to February was shown by Least Sandpipers, declining from 32,000 to 3000, nearly a 90% drop. Did they continue farther south of Sinaloa in mid-winter? Were they already headed north in February? On the other hand, dowitchers increased from 10,000 in December to over 70,000 in February, and Willets from about 2000 to 6000. These numbers probably reflect the early stages of spring migration.

We hope that our data will pique the interest of shorebird biologists to initiate detailed studies of Neotropical migrant shorebirds along their migratory paths. Despite the preliminary nature of our findings, we urge authorities in Mexico charged with managing coastal wetlands to move now to protect what clearly is one of the most important shorebird resources on Earth. Already competing economic development has moved into both bays. Continued destruction would be a biological tragedy of enormous proportion and could have devastating effects to the Neotropical migratory shorebirds of the Americas.

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